

ON SOLAR CHANGES OF TEMPERATURE AND VARIATIONS IN RAINFALL IN THE REGION SURROUNDING THE INDIAN OCEAN.¹

II.

Indian Rainfall. S.W. Monsoon, 1877-1886.

IT will be clear from what has been stated that our object in studying rainfall was to endeavour to ascertain if the + and - temperature pulses in the sun were echoed by + and - pulses of rainfall. The Indian rainfall was taken first, not only because in the tropics we may expect the phenomena to be the simplest, but because the regularity of the Indian rains had broken down precisely when the widened line observations showed a most remarkable departure from the normal.

It was also important for us to deal with the individual observations as far as possible, because it was of the essence of the inquiry to trace the individual pulses if they were found. Hence the S.W. monsoon was, in the first instance, considered by itself, because although Eliot holds that the winter rains (N.E. monsoon) are due to moisture brought by an upper S.W. current,² their incidence is very different and their inclusion might mask the events it was most important to study.

The first investigation undertaken was the study of the rainfall tables published by the Meteorological Department of the Government of India. These were brought together by Blandford down to the year 1886.³ As the widened line observations were not begun at Kensington till 1879, the discussion was limited in the first instance to the period 1877-1886 inclusive, embracing the following changes in solar temperature, occurring, as will be seen, between two conditions of mean solar temperature:—

Mean	- pulse	Mean	+ pulse	Mean
1876	1877-1880	1881	1882-1886	1886-1887

Bearing in mind that the intensity of the + pulse may in some measure be determined by the solar disturbances, which for the present are registered by spotted area, it is important to point out that the preceding maximum in 1870 was remarkable for obvious indications of great solar activity.⁴

It soon became evident that in many parts of India the + and - conditions of solar temperature were accompanied by + and - pulses producing pressure changes and heavy rains in the Indian Ocean and the surrounding land. These occurred generally in the first year following the mean condition, that is, in 1877-8 and 1882-3, dates approximating to, but followed by, the minimum and maximum periods of sun-spots.

Meldrum, as far back as 1881,⁵ referred to "the extreme

¹ By Sir Norman Lockyer, K.C.B., F.R.S., and W. J. S. Lockyer, M.A. (Camb.), Ph.D. (Gött.) Paper read before the Royal Society on November 22. Continued from p. 109.

² Report, 1877, p. 125.

³ "Indian Meteorological Memoirs," vol. iii.

⁴ "The year 1870 was characterised by an exuberance of solar energy, which is without parallel since the beginning of systematic observations (i.e. since 1825). The number of observed groups far exceeds that of any previous year, and it appears also from a cursory comparison with the maximum year's observations, as recorded by Hofrath Schwabe, that the magnitude of the different groups, as well as the average amount of spotted surface during any period of the year, is unprecedented." (*Monthly Notices*, vol. xxxi. p. 79, Warren de la Rue, B. Stewart, B. Loewy.)

The table which the authors of this paper give shows that during the year, although observations of the sun were made on 213 days out of the 364, there was no day without spots recorded. In fact, during the whole year no less than 403 new groups of spots were noted, thus showing us that on the average there was more than one new group per diem.

The authors further remark, "A very remarkable feature of the groups observed during the year appears to be their extraordinary lifetime. . . an exceedingly large number of groups completed 3, 4, and even more revolutions before finally collapsing."

⁵ "On the Relations of Weather to Mortality, and on the Climatic Effect of Forests."

oscillations of weather changes in different places, at the turning-points of the curves representing the increase and decrease of solar activity."

It was especially in regions such as Malabar and the Konkan when the monsoon strikes the west coast of India, that the sharpness and individuality of these pulses was the most obvious.

One method of study employed has depended upon Chambers's view (*Indian Meteorological Memoirs*, vol. iv. Part 5, p. 271) that the S.W. monsoon depends upon the oscillations of the equatorial belt of low pressure up to 31° N. lat. at the summer solstice. The months of rain-receipt on the upward and downward swing will therefore depend on the latitude, and these months alone have been considered.

We began by taking elevated stations in high and low latitudes.

Leh Lat. 34° N. 11,500 feet	The 1881 pulse (in July) was the heaviest recorded (1.77 inches) save one in 1882; the rainfall was nearly as high. The pulse felt in 1878 was the highest of all. The 1881 pulse (Aug.) is high, but is followed by a higher next year. The 1878 pulse (Aug.) is highest of all. Taking the fall in July and Aug. The 1881 pulse occurs in 1882, and is highest. Next comes the pulse in 1878.
Murree Lat. 33° N. 6344 feet	
Newera Eliya Lat. 7° N. 6150 feet	

It must also be stated that if we take the sun-spot maximum, including the period we have chiefly discussed (1877-1886), as normal, it is found that there are variations in rainfall accompanying the preceding and succeeding maxima of 1870 and 1893. This variation indicates the existence of a higher law, but there has not been time to discuss them thoroughly enough to justify any definite statements about them.

The Rainfall of "Whole India."

The next step was to work on a longer base, and for this purpose Eliot's whole India table of rainfall, 1875-1896 (*NATURE*, vol. lvi. p. 110), embracing both the S.W. and N.E. monsoons, being at our disposal, was studied.

It was anticipated that such a table, built up of means observed over such a large area and during both monsoons, would more or less conceal the meaning of the separate pulses observed in separate localities; this we found to be the case. But, nevertheless, the table helped us greatly, because it included the summation of results 9 years later than those included in Blandford's masterly memoir. Predominant pulses were found in 1889 and 1893, following those of 1877-8 and 1882-3. So that it enabled us to follow the working of the same law through another sun-spot cycle, the law, that is, of the mean solar temperature being followed by a pulse of rainfall.

Mean sun	Rain pulse
1876	- 1878
1881	+ 1882
1886-7	- 1889
1892	+ 1893

The main feature of this table is the proof of a tremendous excess of rainfall in 1893—by far the greatest excess of all (percentage variation, + 22). This was far greater than the excess in 1882.

The next remarkable excess occurs in 1878 (percentage variation, + 15).

The pulses in the period stand as follows:—

	Percentage variation	Heat pulse		Years after
— Min. 1878	+ 15	—		rise of
— Max. 1882	+ 6	+	Years after	iron
— Min. 1889	+ 6	—	rise of	lines.
— Max. 1893	+ 22	+	unknown	
			lines.	

The variations in the intensities of the pulses of rain at the successive maxima and minima are very remarkable, and suggest the working of a higher law, of which we have other evidence. But, putting this aside for the present, it should be pointed out that even normally we should not expect the same values for the rainfalls in 1882 and 1893, because the amount of spotted area was so different, 1160-millionths of the solar surface being covered with spots in 1883, and 1430 in 1893.

The very considerable variation in the quantity of snowfall on the Himalayas has often been pointed out by the Indian meteorologists. We have, therefore, used the "whole India" curve between 1875 and 1896, to see whether the sun pulses, which we have found to be bound up with the Indian rainfall, are in any way related to the snowfall as might be expected.

The Himalayan snowfall beyond all question follows the same law as the rain, the values occurring at the + and - pulses, as under, being among the highest:—¹

	inches
— - 1867-8 ...	134
— + 1871-2 ...	110
— - 1877-8 ...	207
— + 1882-3 ...	81

From these tables it follows that both in rainfall and snow the quantity is increased in the years of the rise both of the unknown and iron lines.

Other Rainfalls.

Being in presence of pulses of rainfall in India during the south-west monsoon, corresponding with pulses of solar change, it became necessary to attempt to study their origins. We may add that other pulses were traced, especially one in 1875, but the simplest problem was considered alone in the first instance.

The rainfalls at the Mauritius, Cape Town and Batavia were collated to see if the pulses felt in India were traceable in other regions surrounding the Indian Ocean to the south and east.

The Mauritius Rainfall.

The rainfall of Mauritius has been obtained by utilising the results that have been published in the Blue Books² issued by the Royal Alfred Observatory since the year 1885. The volume for 1886 gives the yearly total rainfall for every station that was then in use from 1861 up to the year 1885, and these values have been employed; since then the yearly values have been obtained direct from each of the yearly volumes subsequently published, *i.e.* to the end of the year 1898.

It was at first thought that the total Mauritius rainfall could be fairly obtained by employing for the period between 1861 and 1886 the means of several stations as given by Meldrum,³ and continuing the values from the observations published in the more recent yearly volumes.

It was found, however, that from 1861-1880 the rainfall was obtained from the observations of four stations, while from 1871-1886 the observations from eight stations were employed.

As a study of all the published data showed that more stations might be utilised in determining the total rainfall of Mauritius, it was decided to discuss all the observations afresh, and make use of as many as possible.

To this end the records of twenty-eight stations,

situated in six different districts, were chosen, and the total rainfall for each year obtained. It is only natural that the number of rain-gauge stations in the early year of 1860 was not so numerous as that of more recent years; the facts may be stated as follows:—

Years.	Mean yearly rain-fall variation from normal.	No. stations used.	Years.	Mean yearly rain-fall variation from normal.	No. stations used.
	Inches.			Inches.	
1861	+ 26.6	1	1880	- 19.3	23
1862	- 10.2	4	1881	- 7.3	25
1863	+ 9.6	6	1882	+ 16.6	25
1864	- 12.2	8	1883	+ 1.8	26
1865	+ 22.6	10	1884	- 12.4	25
1866	- 18.2	10	1885	- 9.8	26
1867	- 6.6	11	1886	- 35.3	26
1868	+ 27.1	11	1887	- 4.2	27
1869	- 3.3	12	1888	+ 22.3	26
1870	- 3.6	12	1889	+ 18.4	24
1871	- 18.9	13	1890	+ 1.2	25
1872	- 7.0	13	1891	+ 1.4	26
1873	+ 10.3	13	1892	+ 5.1	19
1874	+ 17.4	17	1893	- 7.4	24
1875	+ 3.0	15	1894	- 0.6	24
1876	- 6.5	17	1895	+ 10.0	21
1877	+ 31.4	19	1896	+ 17.6	22
1878	- 3.8	22	1897	- 19.6	24
1879	- 5.2	22	1898	- 2.1	24

With regard to the general rainfall of Mauritius throughout the year, it may be stated that on the average the most rainy months are from December to April, both months inclusive.

The months of November and May are those in which the daily rainfall is increasing and diminishing respectively. Sometimes in July or August there is a slight tendency for a small increase.

The Mauritius Rainfall Curve for the period 1877-1886.

In plotting the Mauritius rainfall curve for the period 1877-1886, it was observed that the curve is of a fairly regular nature, showing alternately an excess and deficiency of rainfall.

The highest and lowest points of the curve will be gathered from the following table:—

Year.	Maximum.	
	Excess.	Deficiency.
1877	31.4	—
1880	—	19.3
1882	16.6	—
1886	—	35.3

Comparing the times of occurrence of the two pulses of rainfall at Mauritius with the times of the crossings of the known and unknown lines, it is found that the Mauritius maximum rainfall of 1877 occurs about a year after the rise of the known lines in 1876. The next Mauritius pulse of rainfall in 1882 follows the succeeding crossing, when the unknown lines are going up, also about a year later.

Comparison of the Mauritius Rainfall with those of Leh, Murree and Newera Eliya for the period 1877-1886.

The most prominent feature of the Mauritius rainfall for this period was the great excess in the years 1877 and 1882.

¹ *I.M.M.*, vol. iii. p. 235.

² "Mauritius Meteorological Results."

³ 1861-1880. Relations of Weather to Mortality, &c., 1881, p. 36. 1871-1886. Annual Report of the Director of the Royal Alfred Observatory for 1886, p. 18.

Both of these pulses have corresponding maxima in the curves for the rainfalls of Leh, Murree and Newera Eliya, the dates of these in all three cases being 1878 and 1882.

The delay of about a year in the effect of the Mauritius pulse being felt in Ceylon and India is exactly what would be expected if the rain at sun-spot minimum comes from the south, as has been surmised.

The fact that the pulses at Mauritius, Ceylon and India in 1882 occur simultaneously is very strong evidence in favour of an origin in the equatorial region itself for the Indian rain at sun-spot maximum. The pulse at maximum in the Indian south-west monsoon may depend to a large extent upon the action of the excess of solar heat on the equatorial waters to the south of India, and not on an abnormal effect on the south-east trade.

We have found that there was a defect of the usual rainfall at Mauritius in 1892-3, and yet the rain supply in India was in excess.

from time to time in the Southern Ocean. In his "Annual Summary" for 1896 he wrote as follows:--

"It has apparently been established in the discussion that the variations of the rainfall in India during the past six years are parallel with, and in part, at least, due to variations in the gradients, and the strength of the winds in the south-east trade regions of the Indian Ocean. The discussion has indicated that there are variations from year to year in the strength of the atmospheric circulation obtaining over the large area of Southern Asia and the Indian Ocean, and that these variations are an important and large factor in determining the periodic variations in the rainfall of the whole area dependent on that circulation, and more especially in India. It has also been indicated that these variations which accompany, and are probably the result in part of abnormal temperature (and hence pressure) conditions in the Indian Ocean and Indian monsoon area may be in part due to conditions in the Antarctic Ocean, which also

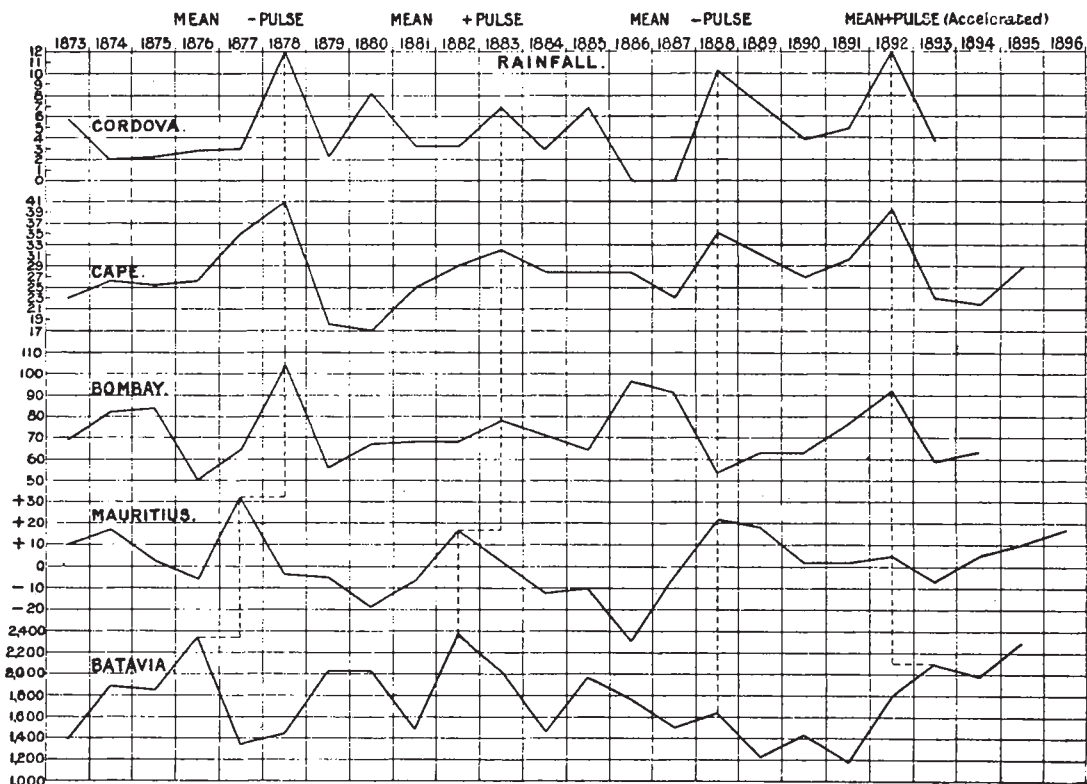


FIG. 1.

RESULT OF THE COMPARISON OF RAINFALL.

The + and - Pulses.

It seems quite certain that we are justified in associating the 1878 pulse of rainfall during the south-west monsoon in India with the rainfall common to Mauritius, Batavia and the Cape at that date; that in all cases the rain has been associated with some special condition connected with the south-east trade in the Indian Ocean.

The rainfall of Cordoba suggests that the same trade wind in the Atlantic Ocean was similarly affected at the same time.

The Cause of the - Pulse.

Mr. Eliot long ago conjectured that the rainfall of India was profoundly modified by events taking place

determine the comparative prevalence or absence of icebergs in the northern portions of the Antarctic Ocean."

We have begun an investigation into the pressure changes which have been recorded in this region, but it will be some time before it is finished. The idea underlying the inquiry is that the reduced solar temperature may modify the pressure so that the high pressure belts south of Mauritius may be broken up and thus allow cyclonic winds from a higher latitude to increase the summer rains as they certainly were increased at the normal minima of 1877 and 1888.

It has been shown that the - pulse is felt in India about a year later than it commences action in the southern oceans; while in some cases the + pulse is felt almost simultaneously in India and at the southern stations.

The Rainfall at the Cape, Batavia and Cordoba for the Period 1877-1886.

Each of the curves illustrating the rainfall for the Cape and Cordoba for this period shows two prominent maxima in the years 1878 and 1883; these correspond nearly with the + and - pulses of solar temperature. Comparing them also with the Bombay and Mauritius curves for the same period, it is found that the pulses indicated at Bombay occur simultaneously with those of 1878 and 1883, but in the case of Mauritius the effect of each of the pulses is felt about a year or so earlier, namely 1877 and 1882 (Fig. 1).

The rainfall curve for Batavia for this period has its most prominent maximum in the year 1882, like that of Mauritius, thus preceding by a year the pulse felt at the Cape, Cordoba and Bombay in 1883.

The Time Conditions of the Pulses.

The various curves which we have drawn for the purposes of study have been compiled from yearly means,

generally to be the case. Thus after the mean solar temperature of 1876, the - pulse was felt first at Mauritius, then in India and the Cape. After the mean of 1881, the + pulse was felt first at Mauritius, then in India and the Cape. Cordoba felt both pulses in the same year as India and the Cape.

Subsidiary Pulses.

In a normal sun-spot curve we find a sharp rise, generally taking three or three and a half years, to maximum, and a slow decline to minimum, on which the remaining years of the cycle are spent.

The curve on the upward side rises generally regularly and continuously; on the downward portion the regularity of the curve is very often broken by a "hump" or sudden change of curvature. There has not yet been a complete discussion of the number and character of the prominences associated with the spots during the cycle; we have found, however, that the "hump" in the sun-spot curve in 1874 was accompanied by a remarkable increase in the number of eruptive prominences.

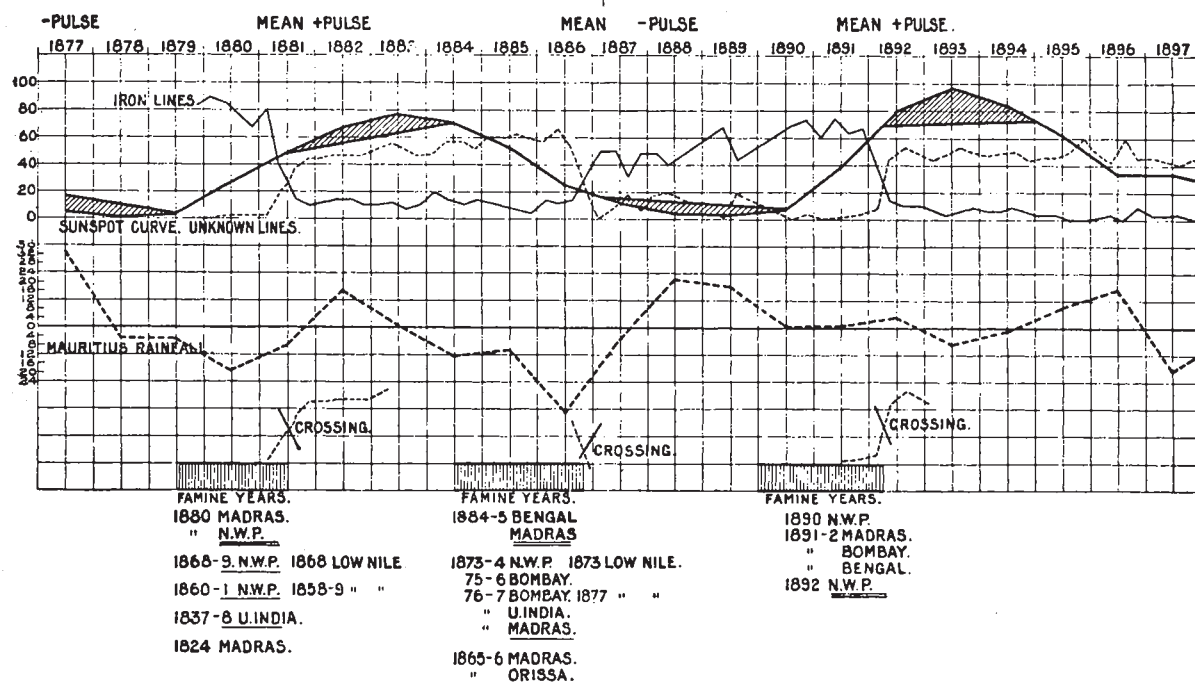


Fig. 2.

and, so far, in these curves the rainfall in months has not been considered. That will have to come later. Hence if the rainfall which most influences the yearly mean occurs in the last three months at one place, and in the first three months of the next year at another, they are shown as being a year apart, whereas they have actually been continuous.

With regard to the travel of the pulses over large areas under the influence of the S.E. trade, it may be gathered from the pressure charts that the + and - conditions of pressure are apt to lie over the centres of land and water areas, and not generally over coast lines. In the case of water surfaces, the effect of a sudden change in the solar radiation on the pressure might be expected to be felt not at the point where the pressure is least or greatest at the time, and of the most general type, but where the equilibrium is most unstable. On the other hand, more time would be required for the new pulse to establish itself where the conditions are more complicated.

Hence we should expect the pulses to be felt first in the eastern part of the southern ocean, and this seems

We have already referred, in discussing the Indian rainfall, to a remarkable intensification of the south-west monsoon in 1874-5, the effect of which is especially noticeable in the rainfall of the Konkan and North-West Provinces, and we have come to the conclusion that we must consider all these events as due to a common cause, that is, to a subsidiary solar pulse. We propose to return to this subject in a subsequent communication, after inquiries have been completed relating to 1885-6 and 1896-7.

The Intervals between the Pulses.

There will obviously be intervals between the ending of one pulse and the beginning of the next, unless they either overlap or become continuous.

The + and - pulses, to which our attention has been chiefly directed, are limited in duration; and when they cease the quantity of rain which falls in the Indian area is not sufficient without water storage for the purposes of agriculture; they are followed, therefore, by droughts, and at times subsequently by famines.

Taking the period 1887-89 we have (Fig. 2)

Rain from	{ 77
- pulse	{ 78
	{ 79 (part)
No rain pulse	{ 79 (part)
	{ 80 (central year)
	{ 81 (part)
	{ 81 (part)
Rain from	{ 82
+ pulse	{ 83
	{ 84 (part)
	{ 84 (part)
No rain pulse	{ 85 (part)
	{ 86 (part)
	{ 87 (part)
Rain from	{ 87 (part)
- pulse	{ 88
	{ 89

1880 - 11 = 1869, N.W.P. famine (1868-9).
 1869 - 11 = 1858, N.W.P. famine (1860).
 1858 - 11 = 1847.
 1847 - 11 = 1836, Upper India famine (1837-8).
 (Great famine).

The interval between the pulses, taking 1885-6 as the central years, on the descending curve.

1885-6 { Bengal famine } (1884-5).
 { Madras famine }
 1885-6 - 11 = 1874-5, N.W.P. famine (1873-4).
 Bombay famine (1875-6).
 Bombay famine
 Upper India famine } (1876-7).
 1874-5 - 11 = 1863-4, Madras famine } (1865-6).
 Orissa famine }
 1863-4 - 11 = 1852-3, Madras famine (1854).

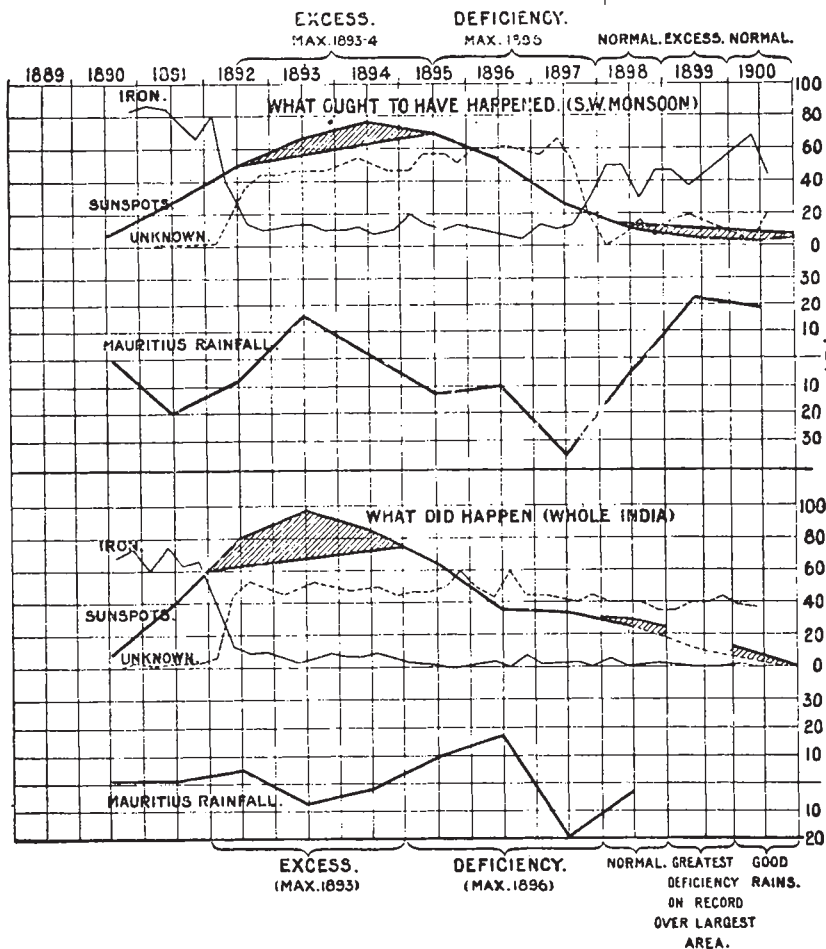


FIG. 3.

The duration of these + and - pulses of rainfall was determined in the first instance by the Mauritius rainfall, which shows both pulses; and later from the Malabar rainfall, which perhaps shows the effect of the south-west monsoon in its greatest purity.

All the Indian famines since 1836 (we have not gone back further) have occurred in these intervals, carried back in time on the assumption of an 11 year cycle.

The following tables show the result for the two intervals:—

The interval between the pulses, taking 1880 as the central year, on the upward curve.

1880, Madras famine.
 N.W.P. famine.

It is clear from the above table that if as much had been known in 1836 as we know now, the probability of famines at all the subsequent dates indicated in the above tables might have been foreseen.

The region of time from which the above results have been obtained extended from 1877 to 1886. The next table will show that if the dates, instead of being carried back, are carried forward, the same principle enables us to pick up the famines which have devastated India during the period 1886-97.

Same intervals, going forward.

1880.
 + 11 1891, N.W.P. famine (1890).
 Madras famine }
 Bombay famine } (1891-2).
 Bengal famine }
 1885-6
 + 11 1896-7, General famine.

This result has arisen, so far as we can see, from the fact that the + and - pulses included in the period 1877-1886 were normal, that is, were not great departures from the average.

Nile Floods.

After we had obtained the above results relating to the law followed by the Indian famines, we communicated with the Egyptian authorities with a view of obtaining data for the Nile Valley.

We have since found, however, from a memorandum by Eliot,¹

that Mr. Willcocks, in a paper read at the Meteorological Congress at Chicago, remarked that "famine years in India are generally years of low flood in Egypt."

It remains only for us, therefore, to point out that the highest Niles follow the years of the + and - pulses. Thus:—

1871, one year after + pulse 1870.
 1876, two years after subsidiary pulse of 1874.
 1879, two years after - pulse 1877.
 1883-4, one and two years after + pulse 1882.
 1893-4, after + pulse 1892 (India excess rainfall, 1892-3-4).

¹ Forecast of S.W. Monsoon rains of 1900.

The Great Indian Famine of 1899.

When, in a sun-spot cycle, the solar temperature is more than usually increased, the regularity of the above effects is liable to be broken, as the advent of the - pulse is retarded.

This, as we have already pointed out, is precisely what happened after the abnormal + heat pulse of 1892, following close upon the condition of solar mean temperature.

The widened line curves, instead of crossing, according to the few precedents we have, in 1897 or 1898, have not crossed yet—that is, the condition of ordinary solar mean temperature has not even yet been reached.

We have shown that, as a matter of fact, in a normal cycle India is supplied from the southern ocean during the minimum sun-spot period, and that this rain is due to some pressure effect brought about in high southern latitudes by the sun at - temperature.

As the - temperature condition was not reached in 1899, as it would have been in a normal year, the rain failed (Fig. 3).

We may say then that the only abnormal famine recorded since 1836 occurred precisely at the time when an abnormal effect of an unprecedented maximum of solar temperature was revealed by the study of the widened lines.

TABLE

Showing the Occurrence of the + and - Rainfall Pulses in other parts of the World.

	+	-	+	-	+
	1870	1877	1882	1886	1892
Batavia ...	—	1876	1882	1888	(?)
Mauritius ...	—	1877	1882	1888	1892
Catherinenburg (Russia) ...	—	1877	abs.	1887-8	1892
Scotland ...	—	1877	—	—	1892
Copenhagen ...	1872-3	1877	1882	1888	1891
Adelaide ...	1870	1877	1883	1889	1892-3
Tiflis ...	1870	1878	1881	1886-90	1893
Archangel ...	1872	1878	1881-2	1887-8	1892
Brussels ...	—	1878	1882	1888	1892
Hobart Town ...	—	1878	1882	1887	1893
Malabar ¹ ...	1871	1878	1882	1888	1892
Toronto ...	1870	1878	1883	1886	1893
Cordoba (Arg.) ...	—	1878	1883	1888	1892
Cape ...	—	1878	1883	1888	1892
Java ...	1872	1879	1882	—	1893
Barnaul (Russia) ...	1872	1879	1882-3	1887	1894
St. Petersburg ...	1871	1879	1883	1888-9	1893
Nile ...	1871	1879	1883-4	—	1893-5

¹ For comparison.

THE BRADFORD MUNICIPAL TECHNICAL COLLEGE.

PROF RÜCKER recently distributed the prizes at the Technical College at Bradford, which was taken over by the municipality a year ago, and is now controlled by a Committee of the City Council. The following is an abstract of his address:—

It would be trite to dwell at length on the changes which have taken place in the educational standards during the last quarter of a century. Then Mr Forster's Education Bill had only been in operation for five years. Now we have free elementary education, and a large sum has been provided for technical education. Two new Universities have been founded and a third, after fifty years' examining, is at length about to teach. Education is not now regarded as the task of a few dons and

professors and schoolmasters. It is a matter which the Cabinet discusses, together with the issues of peace and war, and with the federation of daughter States into a Commonwealth. Nay, and in the great spread of local self-government, when Town Councils decide questions which affect more people than constituted, in the beginning of the century, many an independent German State, education is not forgotten; and here in Bradford you have the whole authority and power of your great municipality brought to bear to form a technical school which will support the industries on which your prosperity depends.

And yet, gentlemen, in the midst of all this eager and fruitful effort how difficult it is to decide what the ideal system of education should be. For in any such system two things must be considered, the welfare of the individuals taught and the welfare of the community of which they are a part; and at first sight these two do not always seem to be identical. Each man, the State may say, has a task to perform, which, if he performs it well, is for the good of the community, and, provided he is a good citizen, I care only about his special task. This man may have to dispense justice. My only concern is that he should be a just and learned judge. That man is to be a manufacturer. If he manufactures well, that is all the State need care for. But surely this view only needs stating clearly to show that there must be a fallacy somewhere. Like the old political economy, it assumes that man lives by bread alone. At the best he cannot always be working, and his own happiness—aye, and the good of the State, too—may be affected by whether his amusements are refined or low, upon whether they elevate or debase him. From this point of view the best educators would be insects, which, like ants or bees, have developed special forms of workers, or soldiers, or drones; or even, as is, I believe, the habit of one species, use an individual to store their food till it becomes a mere bloated honey-bag.

Others hold the opposing view. The object of education, they say, is to educate—that is, to bring out the latent capacities of the mind. Provided this end is achieved, it matters little how this is done; but, on the whole, it is better that the subjects taught should be selected rather because they illustrate general principles than because they are likely to be immediately useful. This ideal is to be condemned because it is impracticable for all but the few. It never has been the system adopted for the working man, and has been very imperfectly adopted for the great bulk of the commercial and professional classes. In the stress and struggle of modern life it is becoming more and more difficult to adopt it for anybody, and common sense revolts against the idea that the utility of the subject taught, or of the method of teaching it, is of secondary importance.

We come, then, to the conclusion that the truth lies somewhere between these two extremes, and that the best education is that which will prepare a man for his walk in life, and will also, as far as may be, keep his mind open to interests and ideas other than those upon which his success as a bread-winner directly depends.

I will not attempt, in the short time at my disposal, to sketch out a general system of education in which these conditions would be fulfilled, and, if I did, I should throughout be conscious that I was only throwing an apple of discord among educational experts.

But, taking scientific and technical education as a whole, I am clear that for the better students, at all events, the study of science should be relieved and aided by the study of modern languages.

Nowadays everything is becoming more cosmopolitan. Science is becoming more international. Only this summer I attended the first meeting of a new association of all the great scientific academies of the world. Again, with the new century will begin the publication of an